TECHNICAL NOTES

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RESISTANCE OF STREAMLINE WIRES

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Summary

This note contains the results of tests to determine the resistance of four sizes of streamline wire. The investigation was conducted in the six-inch wind tunnel of the National Advisory Committee for Aeronautics. The tests were made at various velocities and it was found that the resistance of streamline wires was considerably less than that of round wires of equivalent strength. Scale effect was also found since, with an increase of Reynolds Number, a decrease in the resistance coefficient was obtained.

The tests were conducted in the six-inch open-throat wind tunnel of the National Advisory Committee for Aeronautics at Langley Field, Virginia, to determine the resistance of a series of streamline wires. Very little information was available from previous tests on this type of wire. The results of these tests are compared with those of a streamline wire in the variable density wind tunnel, and with the curves given by Prandtl and Bairstow for the resistance of round wires. The sizes of wire tested were as follows:

d (thickness)	l (length of cross section)
0.025 in.	0.092 in. (special size wire)
0.098	0.362
0.138	0.544
0.181	0.754

The last named three sizes correspond to streamline wires in general use.

The wires were fastened in a square wooden frame which was attached to the wire balance in the wind tunnel. The number of wires used depended on the size, since it was necessary to have a total length of wire which would cause a large enough resistance to move the wire balance. The wires in each frame were spaced at intervals of five times the thickness of the wire used, which was considered sufficient to eliminate interference between them. The wires extended through the air stream in the horizontal direction, and were spaced in the vertical direction to use the central four inches of the six-inch air stream.

Tests were made at velocities from 35 M.P.H. to 105 M.P.H., the drag force being measured at each velocity. The coefficients were calculated from the following:

$$C_D = \frac{\text{Drag}}{q\ d\ L}$$

$$\text{R.N.} = \frac{\rho V l}{\mu} = \frac{l}{\mu}\sqrt{2}\sqrt{\rho q} = 1.414\frac{l}{\mu}\sqrt{\rho q}$$

where

C_D = absolute drag coefficient

R.N. = Reynolds Number

q = dynamic pressure, $\frac{1}{2}\rho V^2$

V = velocity

ρ = density of air

μ = coefficient of viscosity

d = thickness of wire

l = length of cross section

L = length of wire

For use in the computations, an average q, of the air stream was obtained from a survey made across the throat of the tunnel in the vertical plane where the wires were located. A diagram of q was plotted for the position of each wire. The distance between the points where q was zero was taken as the length of wire in the air stream. An average q over this length of wire was found by dividing the area of the q diagram by the distance between the points of zero q. Using these average values of q over each length of wire, an average value over the total length of wire was found by multiplying the values of q by their corresponding lengths of wire and dividing the sum by the total length of wire. This is the value of q used in computing the drag coefficient and the average velocity.

The results of the tests are given in Table I and are plotted in Figures 1-3. In Figures 1 and 2, the curves of drag coefficient against Reynolds Number are plotted for each set of wires of the same size. This data together with the drag coefficients from a test on a streamline wire 0.138 in. by 0.542 in. conducted in the variable density wind tunnel are plotted in Figure 3. A curve is drawn through the experimental points which is common to all of the tests of different sizes of wire. Curves of the resistance of round wires given by Prandtl and Bairstow are also plotted in Figure 3. Values of the drag coefficients in these tests were found at Reynolds Numbers below those obtained in the previous test.

It is evident that there is close agreement between the curves of the drag coefficients obtained in the various tests. A comparison of resistance coefficients for round wires and streamline wires indicates that an appreciable reduction in the resistance may be made by the use of streamline wires in model tests in the wind tunnel and in the rigging of airplanes and airships. The results indicate that the drag coefficient is the same for the different sizes of wire at the same value of the Reynolds Number. As the Reynolds Number increased, the resistance coefficient decreased.

TABLE I.

Resistance Coefficients of Streamline Wires.

Size Wires 0.025 in. by 0.092 in.			Size Wires 0.098 in. by 0.362 in.		
Velocity M.P.H.	R. N.	C_D	Velocity M.P.H.	R. N.	C_D
35	2,360	0.5560	35	9,290	0.4038
50	3,340	0.5040	50	13,200	0.3718
61	4,100	0.4510	61	16,100	0.3410
61	4,090	0.4395	70	18,350	0.3410
70	4,730	0.4340	78	20,500	0.3290
78	5,290	0.4165	78	20,300	0.3228
85	5,740	0.4050	78	20,300	0.3351
85	5,750	0.3930	85	22,300	0.3310
93	6,200	0.3770	93	24,000	0.3233
99	6,700.	0.3640	93	24,100	0.3145
105	7,150	0.3630	99	25,600	0.3062
			99	25,900	0.3025
			105	27,100	0.3069
			105	27,200	0.3000

TABLE I (Cont.)

Resistance Coefficients of Streamline Wires.

Size Wires 0.138 in. by 0.544 in.			Size Wires 0.181 in. by 0.754 in.		
Velocity M.P.H.	R.N.	C_D	Velocity M.P.H.	R.N.	C_D
35	13,750	0.3672	35	19,800	0.3427
50	19,500	0.3433	50	28,000	0.2990
61	23,800	0.3283	61	34,200	0.2849
70	27,600	0.3210	70	38,800	0.2850
78	30,500	0.3090	70	39,600	0.2780
85	33,400	0.3058	78	44,000	0.2851
93	36,000	0.3078	85	47,300	0.2800
99	38,400	0.3032	85	48,000	0.2848
99	38,500	0.3008	93	51,600	0.2810
105	40,500	0.3052	99	55,000	0.2780
			105	57,000	0.2756

TABLE II.

Drag of Wires per foot length at 100 M.P.H.

Streamline Wires

Size	Area sq. in.	R.N.	C_D	Drag lb./ft. length at 100 M.P.H.
0.025 in. × 0.092 in.	0.0018	7,160	0.382	0.0203
0.098 in. × 0.362 in.	0.0279	28,150	0.305	0.0638
0.138 in. × 0.544 in.	0.0590	42,370	0.277	0.0815
0.181 in. × 0.754 in.	0.1070	58,700	0.245	0.0945

Equivalent Round Wire

Size dia.	Area sq. in.	R.N.	C_D	Drag lb./ft. length at 100 M.P.H.
0.048 in.	0.0018	3,740	0.98	0.0999
0.188 in.	0.0279	14,670	1.16	0.4639
0.274 in.	0.0590	21,300	1.19	0.6835
0.369 in.	0.1070	28,800	1.20	0.9420

Langley Field, Va.,

November 17, 1927.

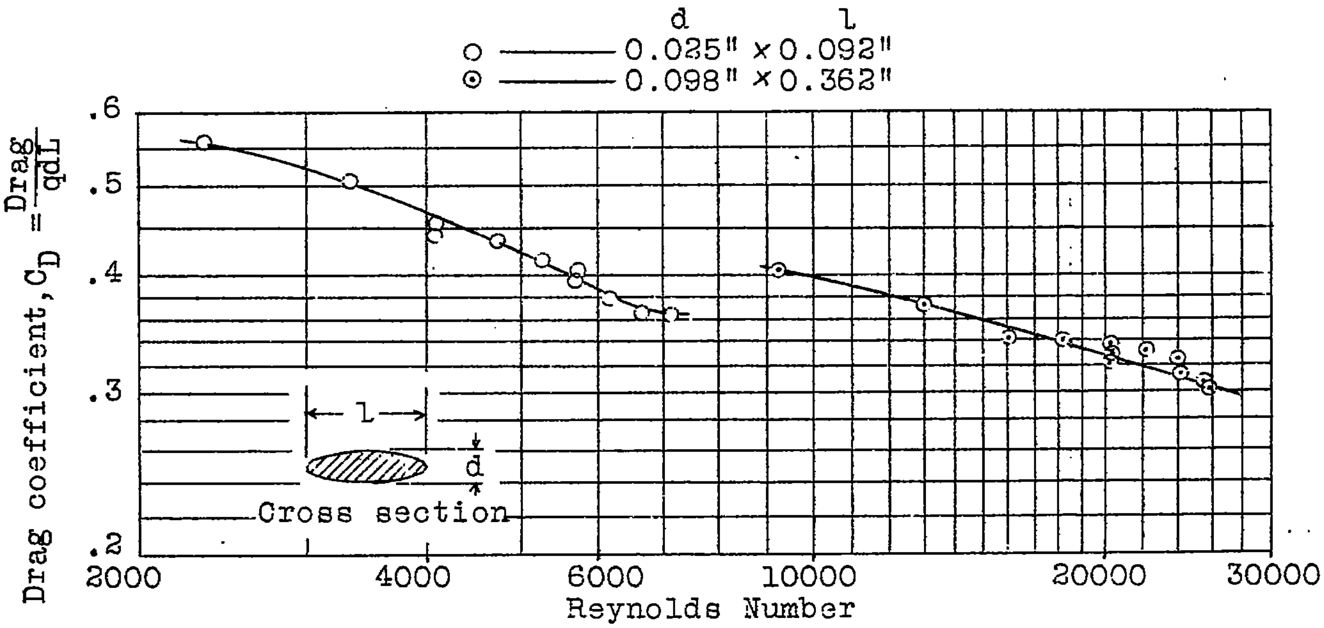

Fig.1

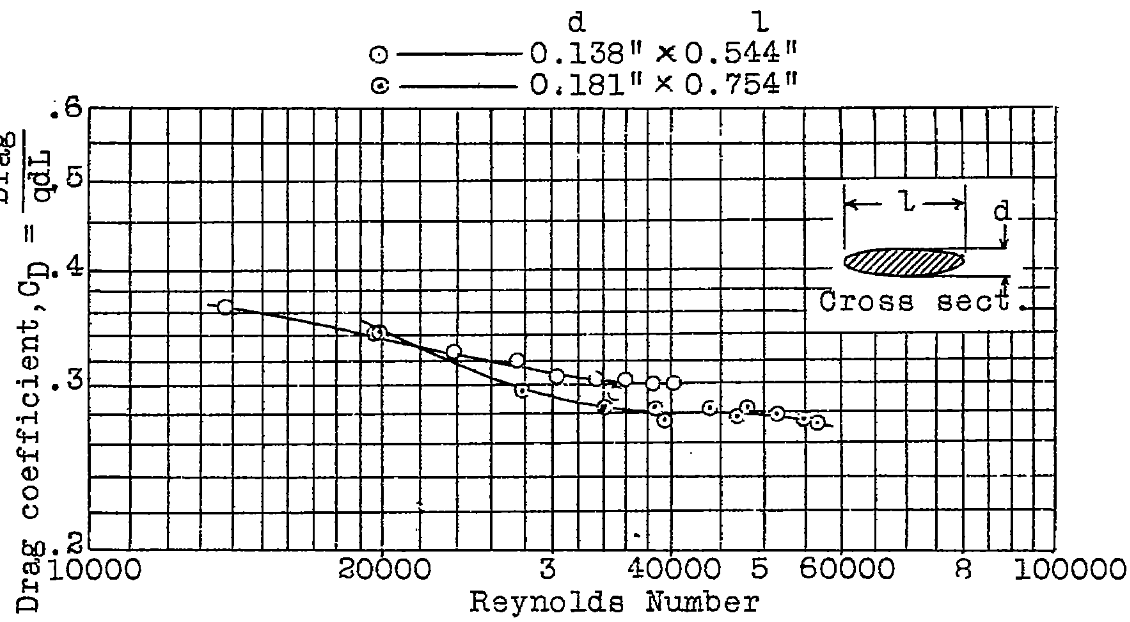

Fig.2

Resistance of streamline wires.

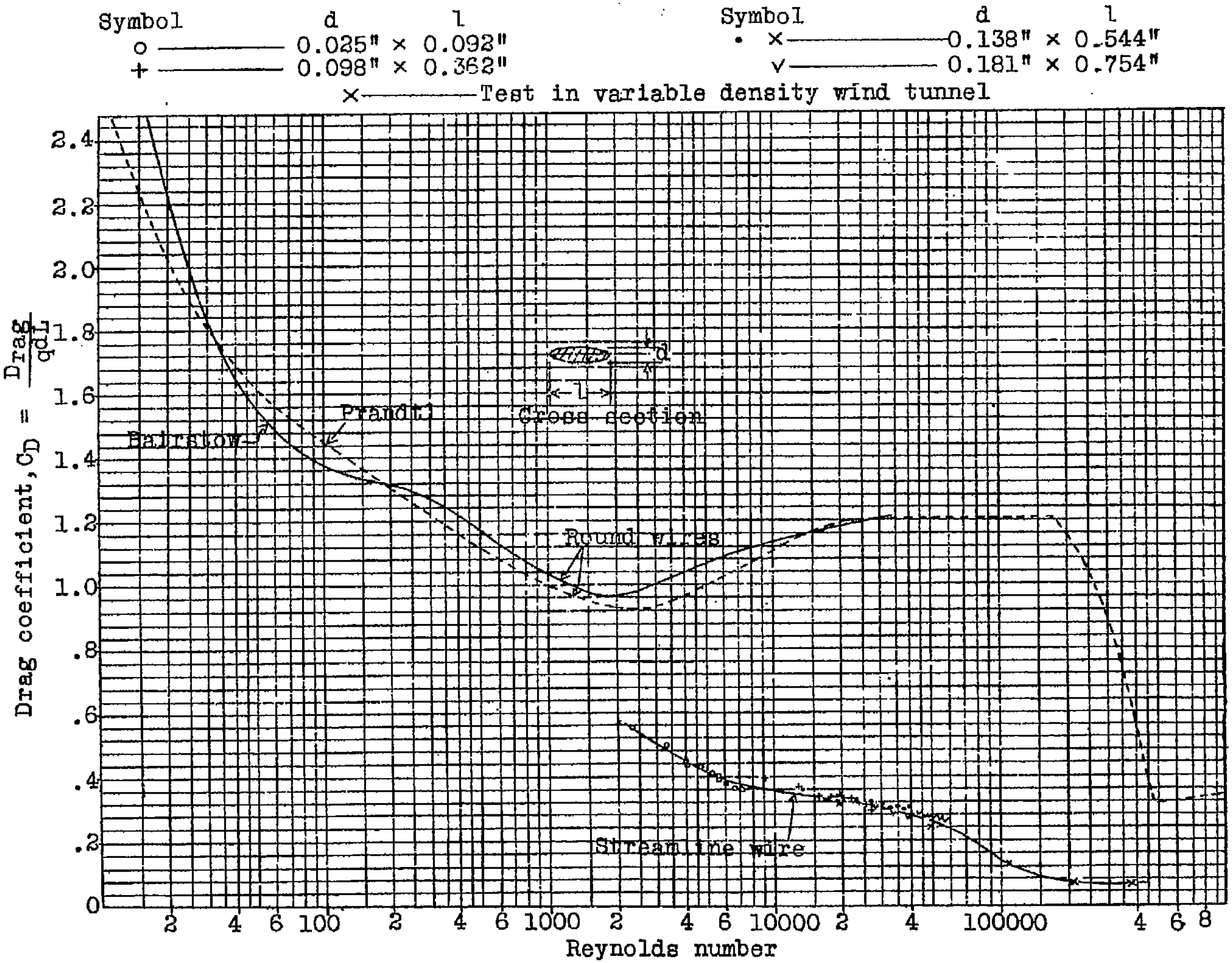

Fig.3 Resistance of streamline wires.